GSFC MO&DSD TECHNOLOGY DEVELOPMENT PLAN

TITLE: **TRACKING & DATA ACQUISITION FUTURE SYSTEMS**	
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BRIEF TECHNICAL SUMMARY *(Objectives and Approach)*

The Tracking & Data Acquisition Future Systems activity addresses several technologies needed for the next generation of tracking and data relay satellites (TDRS's) and their users, as well as follow-on systems. Specific tasks are: the study and development of system level concepts to accommodate new classes of users; study of new Ka-band operations concepts and related technology development; concepts to utilize demand access techniques; and study and development of new techniques for TDRSS orbit determination.

A fifth task in this work element is Advanced Receiver Hardware development. This activity will advance the state-of-the-art in receiver design, operations and performance via the development of PN matched filters using CCD technology and the application of IF sampling techniques to despread the PN code, demodulate, and filter. These techniques will be applied to the design of low-power, low-cost receivers in Space Network space and ground-based transponders and transceivers, as well as in SN and GN ground terminals.

APPROVALS		
WORK AREA MANAGER:	DIVISION MANAGER:	GSFC PROGRAM MANAGER:

JUSTIFICATION AND BENEFITS

Future System Applications

The effort under this task involves predicting future T&DA requirements, conceiving and evaluating system architectures to meet those requirements, and identifying new techniques or technologies that should be developed to fulfill anticipated future requirements. It also includes studies to stay abreast of new technologies in the commercial space communications arena, which may have potential application to future T&DA systems.

As examples of this effort, previous studies under this Task included: Follow-on TDRSS and TDRSS-II, self and mutual interference, beacon services and prototype beacon receiver development, preliminary design and development of an integrated receiver, three node TDRSS constellation, small mission support by TDRSS, demand access concept studies and demonstration, and feasibility study of a low-power CCD correlator chip for handheld TDRSS transceivers.

Ka-band Systems and Technology Study

The next generation TDRS H, I, J spacecraft are functionally equivalent to the existing TDRS with the exception of an added Ka-Band communications payload and an upgraded multiple access capability. NASA has added the Ka-Band capability to respond to increasing congestion in the S-band; to respond to the WARC-92 addition of a primary fixed-satellite service uplink allocation at Ku-Band that introduces potential future interference; and to provide potential benefits to customer spacecraft. Customers can take advantage of the Ka-Band links to transmit higher data rates with the increased bandwidth and can implement smaller antennas on the spacecraft than those required at Ku-Band.

Demand Access Utilization Concepts

A new Demand Access service is being planned for implementation in the Space Network (SN) using the TDRSS multiple access (MA) subsystem to support multiple missions without prior scheduling. The feasibility of the planned service has been established by earlier studies and demonstration. FY97 effort will support the preparation of a detailed operations concept and implementation plan and will develop a software model of the demand access service to illustrate the performance to potential users and to serve as a system engineering and planning tool.

An unscheduled demand access service is extremely attractive to small satellite projects and other low-budget missions that will be able to use the SN for the first time through the use of the 4th generation, low power consumption TDRSS user transponder now under development. Demand access service will provide increased flexibility and lower mission operations costs for S-Band TT&C operations. Use of TDRSS will also eliminate the need for uplink and tracking capability in small satellite ground terminals, allowing less expensive receive-only terminals to be used for science data collection. Further, small satellites using an additional Ku-Band phased array antenna, also under development, can dump their science data to TDRSS instead of to the ground, thereby eliminating entirely the need for a ground terminal.

TDRS Orbit Determination

The Bilateration Ranging Transponder System (BRTS), used for orbit determination of the TDRS constellation, is nearly 15 years old and will need to be replaced soon. It is also necessary to improve the TDRS orbit accuracy from the current 3-sigma value of 150 m to 75 m to meet the user orbit accuracy required by the Mission to Planet Earth (MTPE) program. The Demand Access Ranging and Tracking System (DARTS) concept is being considered as a replacement for BRTS to improve accuracy. Using DARTS the required TDRS orbit accuracy can be achieved by reducing the two major error sources in the current system; ionospheric error; and drifts in system delay through TDRS and the WSC. Novel approaches are being considered for reducing both sources of error. Further, the cost of replacing the BRTS transponders (still required by DARTS) can be reduced by a factor greater than ten by taking advantage of previous investments in the Software Programmable Advanced Receiver (SPAR) and the PORTCOM receiver and transmitter hardware developments. The low implementation cost also makes possible additional unattended sites to further increase accuracy and trajectory recovery response. The evolution of the BRTS enabled by the DARTS concept is a low-risk and cost effective approach to maintaining and enhancing the reliable TDRS orbit determination performance that exists in the Space Network today.

Advanced Receiver Hardware Development

Numerous GN and SN system applications (PORTCOM, TDRSS-mode EUVE support from the ground, ELV support from WSC, and a low-cost receiver/exciter/ranging capability) have grown out of the work previously done in this technology area. Advanced signal processing technologies, such as PN matched filters using CCD technology, and Intermediate Frequency (IF) sampling techniques to despread the PN code, demodulate and filter, have been incorporated in the receiver design. The IF sampling technique has several benefits; simpler RF to baseband conversion through simultaneous demodulation and filtering, optimized efficiency of analog and digital processing using a hybrid design, reduced A/D conversion requirements, inherent configuration flexibility, and enhanced reliability due to fewer components.

FY97 studies and prototyping of ultra low-power components for future receiver implementation will also provide enabling technologies for a new, miniaturized TDRSS transceiver to be used in future Space Network applications.

APPROACH AND PLAN

Future System Applications

The effort under the Future System Applications task involves continuing studies to stay abreast of new technologies in the commercial space communications arena, which may have potential application to future T&DA systems. Specific technologies that may be focused upon include multipath reduction (specifically RAKE receiver implementations), and link performance improvements via such methods as improved error correction codes and data compression. Multiple access modulation methods that increase the number of supported MA users may also be considered. Other, potentially relevant technologies to be studied include the concept of enhancing MA user services via beam splitting and/or multiple concurrent forward link transmissions.

A near-term application of advanced technology to the immediate needs of potential new users of the Space Network will be demonstrated. This specific example is a spread spectrum TDRSS forward link (F/L) receiver, based on Software Programmable Advanced Receiver (SPAR) technology that can be used in applications where higher S-Band forward link data rates (up to 300 Kb/sec) are required.

Ka-band Systems and Technology Study

This activity will study utilization issues for customers of Ka-Band service provided by TDRS's H, I, J and will investigate the availability of space qualified antennas and equipment with acceptable performance, weight, size, power consumption and cost. Key trades will be performed on the identification of available versus needed technologies. Any required technology developments will be defined.

A potentially efficient strategy for the use of Ka-Band will be to use a common Ka-Band phased array, currently being developed, for communications with TDRS's H, I, J for space-to-space data relay to White Sands and also with low-cost terrestrial ground stations for direct space-to-earth return of large volumes of instrument data. A study will be performed to develop an architecture and to select candidate technologies for a prototype Ka-Band ground terminal to implement this dual-use strategy.

Demand Access Utilization Concepts

The demand access study activity will focus on a more detailed operations concept and system design to support forthcoming implementation efforts. The study will also address issues concerning the augmentation of hardware at White Sands required to allocate a dedicated return link to each demand access user that will support random transmissions (science alerts, etc.) from the spacecraft.

Work will begin on a software model of the demand access service that will illustrate the performance of the demand access system to potential users, concurrently aid the system engineering effort, and serve as a prototype planning tool.

TDRS Orbit Determination

The Demand Access Ranging and Tracking System (DARTS) is a candidate system to replace BRTS. It has been proposed to meet or exceed the required improvements in TDRS orbit determination accuracy by addressing the major error sources (ionospheric error and drifts in system delay through TDRS and the WSC) in the current system. Results from a preceding study indicate that both steady state and post-maneuver orbit determination may also be improved by a hybrid approach using both DARTS and tracking information from certain TDRSS user satellites whose orbits are well known using a technique called “Joint TDRSS/User Tracking”.

A study activity will focus on the orbit determination performance of DARTS and augmented DARTS, and the implied operational considerations. Specifically, the operations concept will be refined, long term requirements will be assessed, and sustaining engineering requirements will be examined. The study will also include examination of WSC and user improvements necessary to achieve the orbit determination performance objectives.

Advanced Receiver Hardware Development

An ongoing effort by GSFC and MIT/Lincoln Laboratories will produce a prototype low-power chip (ATC-LP) that will slash the power of the 2ATC chip used in current receiver designs by an order of magnitude and will incorporate an on-chip analog/digital (A/D) converter for more compact, low-power receiver technology in the future. The new ATC-LP design will eliminate most of the static power consumed in the current 2ATC CCD. In the advanced receiver design, the analog outputs of the 2ATC chip require digitization prior to further processing, but the required external A/Ds cause an additional power load for the receiver. However, the incorporation of analog-to-digital conversion directly onto the chip will lower the power consumption of the analog portion of the receiver even further.

To complement the dramatic power reductions of the analog circuitry, an effort is underway to also slash the power consumption of the digital processing circuitry of the receiver as a major step toward a miniaturized, battery-operated TDRSS transceiver. A field programmable gate array (FPGA) to perform the digital processing functions was designed and simulated in FY96. In FY97, the FPGA and evaluation card will be built and tested. Then the FPGA design will be converted into an ASIC implementation for use in a miniaturized TDRSS transceiver.

DELIVERABLES

ITEM	DATE
Future System Applications	
High Rate F/L Receiver Demonstration	12/96
Technology Study Briefings	3/97 & 9/97
Ka-band System & Technology Study	
Ground Terminal Architecture - draft briefing	3/97
Final Report	9/97
Demand Access Utilization Concepts	
Demand Access Concept Studies	9/97
Demand Access Software Model - Initial Capability	9/97
TDRS Orbit Determination	
DARTS Ops Concept and OD Performance Study	9/97
Advanced Receiver Hardware Development	
FPGA Testing & Evaluation	2/97
Complete ASIC Design	9/97

RESOURCE REQUIREMENTS

Task Name	NASA UPN	FY97 *($K)*	FY98 *($K)*	FY99 *($K)*	FY00 *($K)*	FY01 *($K)*	FY02 *($K)*
Tracking & Data Acquisition Future Systems	(315-90-11)	755	755	800	950	950	950

GSFC MO&DSD TECHNOLOGY DEVELOPMENT PLAN

UPN: 315-90-11 TRACKING & DATA ACQUISITION FUTURE SYSTEMS

SCHEDULE

TRACKING & DATA ACQUISITION FUTURE SYSTEMS	FY97				FY98		FY99	FY00	FY01	FY02
	Q1	Q2	Q3	Q4	Q1/2	Q3/4				
Future System Applications										
a. High Rate F/L Receiver Demonstration										
b. Technology Study Briefings										
Ka-band System & Technology Study										
a. Ground Terminal Architecture - Draft Briefing										
b. Final Report										
Demand Access Utilization Concepts										
a. Demand Access Concept Studies										
b. Demand Access Software Model - Initial Capability										
TDRS Orbit Determination:										
a. DARTS Ops Concept and OD Performance Study										
Advanced Receiver Hardware Development:										
a. FPGA Testing and Evaluation										
b. ASIC Design Complete										
Resources by FY ($K):	750				800		800	950	950	950